Institute of Freshwater Ecology

BENTHIC INVERTEBRATE SURVEY - LOCH LEVEN NNR (1994)

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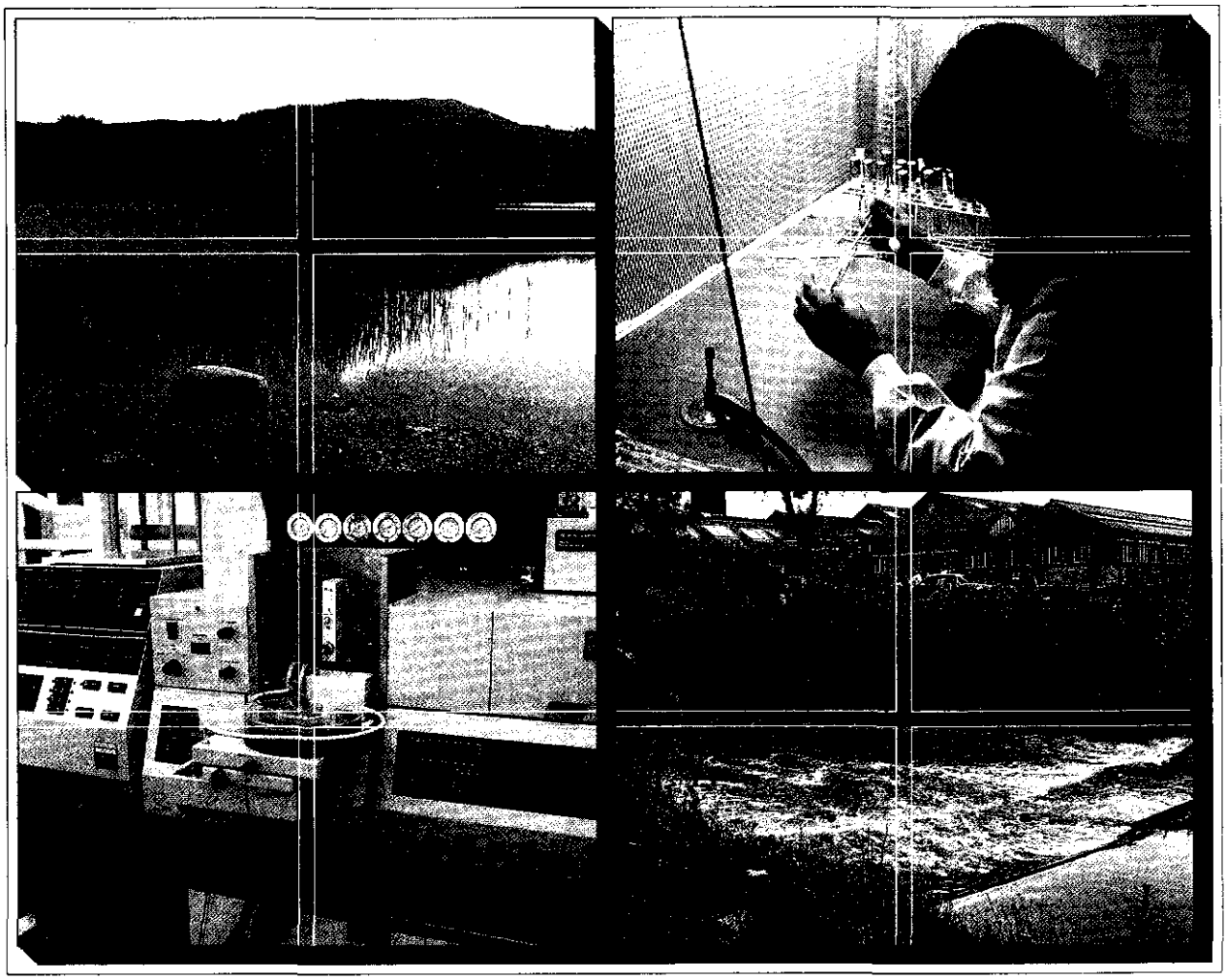

Natural Environment Research Council

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BENTHIC INVERTEBRATE SURVEY - LOCH LEVEN NNR (1994)

SUMMARY

A comprehensive survey of the benthos of the sand and mud sediments of Loch Leven NNR provided an opportunity to compare the results with data derived from IBP studies of the late 1960s and early 1970s, in order to assess the loch's current invertebrate status. The list of recorded taxa was generally similar, with larval Chironomidae and Oligochaeta the dominant groups. The distributional pattern of the invertebrates also remained analogous to that found during IBP; a number of groups showing a distinct preference or were restricted to either the deeper mud areas or the shallower sandy regions. The chironomid community, however, showed considerable changes in the relative abundance of its constituent genera; *Glyptotendipes* and *Polypedilum* which were formerly common are now rare, *Stictochironomus* is more abundant and *Endochironomus*, which had become extinct in Loch Leven, has reappeared, albeit in very low numbers. Other chironomid taxa e.g. *Procladius* and Tanytarsini remain at similar population levels as before. Several new taxa were found, *Paracladopelma*, a chironomid relatively intolerant of eutrophication as well as the oligochaete species *Uncinais uncinata*, *Psammoryctides barbatus* and *Limnodrilus claparedeianus*, which are more associated with eutrophic conditions. A number of invertebrates previously recorded were not found during the survey, although this is probably an inevitable consequence of trying to compare a 'one-off' survey with an intensive survey programme covering a period of several years. Whether these changes in the zoobenthos are a normal part of the invertebrate community cycle or indicative of a more permanent change in its status (e.g. in connection with the attempted nutrient input cutbacks) it is difficult to know, but it does suggest that Loch Leven continues to be an unstable and eutrophic system.

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1. INTRODUCTION/BACKGROUND

Loch Leven became the focus of a huge research effort during the late 1960s and early 1970s as part of the International Biological Programme (IBP). One of the major components of the project was a detailed investigation of the invertebrate benthos, with particular emphasis being placed on production studies (Charles *et al.*, 1974; Maitland, 1979; Maitland and Hudspith, 1974). An initial comprehensive sediment/benthos survey carried out in October 1968, indicated that the main substrate types found in Loch Leven were sand (42%) and mud (57%), both of which had a characteristic invertebrate community associated with them (Maitland, 1979). The macro-invertebrate communities were dominated by Chironomidae, though Annelida, Crustacea, Mollusca and Nematoda were also important (Maitland and Hudspith, 1974). However, Maitland and Hudspith (1974) and Morgan (1970,1974) indicated that the invertebrate community had a reduced species diversity compared to historical records, a decline attributed to the nutrient enrichment of the loch. Due to the evident importance of larval Chironomidae as consumers of primary production and as food for tertiary consumers such as the brown trout *Salmo trutta* L., much of the later invertebrate work concentrated on studying their production.

In the years post-IBP, research at Loch Leven has concentrated on reducing eutrophication and its effects on the loch, particularly in relation to blue-green algae (e.g. Bailey-Watts *et al.*, 1987 & Bailey-Watts *et al.*, 1993). However, little work has been undertaken to accurately monitor and systematically record and publish data on the zoobenthos during this period. Recent research into other aspects of the ecology of Loch Leven, for example, fish stocks, fish diet, macrophytes and wildfowl have all highlighted the need for an update on the current status of the invertebrate fauna. This present contract therefore provides an opportunity to carry out a 'snapshot' survey of the invertebrates of Loch Leven in both the sand and mud sediments by employing a similar methodology to that adopted during the IBP studies. As well as ensuring that the survey is statistically valid, it permits comparisons to be made between the present species composition, abundance and distribution of the benthos with that found during the IBP studies.

2. METHODS

2.1. Field Sampling

The sampling programme was carried out over a period of three days at the beginning of May 1994. Prior to sampling the map of Loch Leven was divided into squares of 0.25ha and grouped regionally, ignoring stony littoral areas and the deeps (**Table 1**). This gave 16 areas (each containing about 145 squares) within the 4 main sand regions and 7 areas (each containing about 378 squares) within the main mud regions. After numbering the squares in each area, 2 were selected from each sand area and 4 from each mud area, using random number tables. This gave a total of 60 sample squares: 32 in sand and 28 in mud. The grid co-ordinates

of each square were then accurately located in the field by the use of a hand-held Global Positioning System (GPS) (**Figure 1**). Details of the sampling points are given in **Tables (2)** and **(3)**. At each sampling point a single core was taken, using a Jenkin corer over mud and a Maitland corer over sand. Both these methods were shown to be the most efficient sampling techniques by Maitland *et al.* (1972). Both methods used perspex coring tubes The tubes were of 6.3 cm diameter for the sand samples and 7 cm diameter for the mud samples. The mud cores were 5 cm in depth; the sand cores varied from 5 to 11.5 cm in depth. The cores were emptied into plastic bags and labelled. Formaldehyde was added to each sample such that with the water already present a final concentration of approximately 4% was obtained. Each bag was then sealed and stored in a cold room prior to the samples being processed and the invertebrates identified.

Table 1. Organisation of main sampling areas and regions within the sand and mud sediments of Loch Leven.

SAND (INSHORE)		MUD (OFFSHORE)
I	A	NORTH (N)
	B	
	C	
	D	NORTH CENTRAL (NC)
II	A	
	B	WEST (W)
	C	
	D	SOUTH CENTRAL (SC)
III	A	
	B	
	C	EAST (E)
	D	
IV	A	SOUTH (S)
	B	
	C	
	D	SOUTH EAST (SE)

Figure 1. Map of Loch Leven showing sampling points.

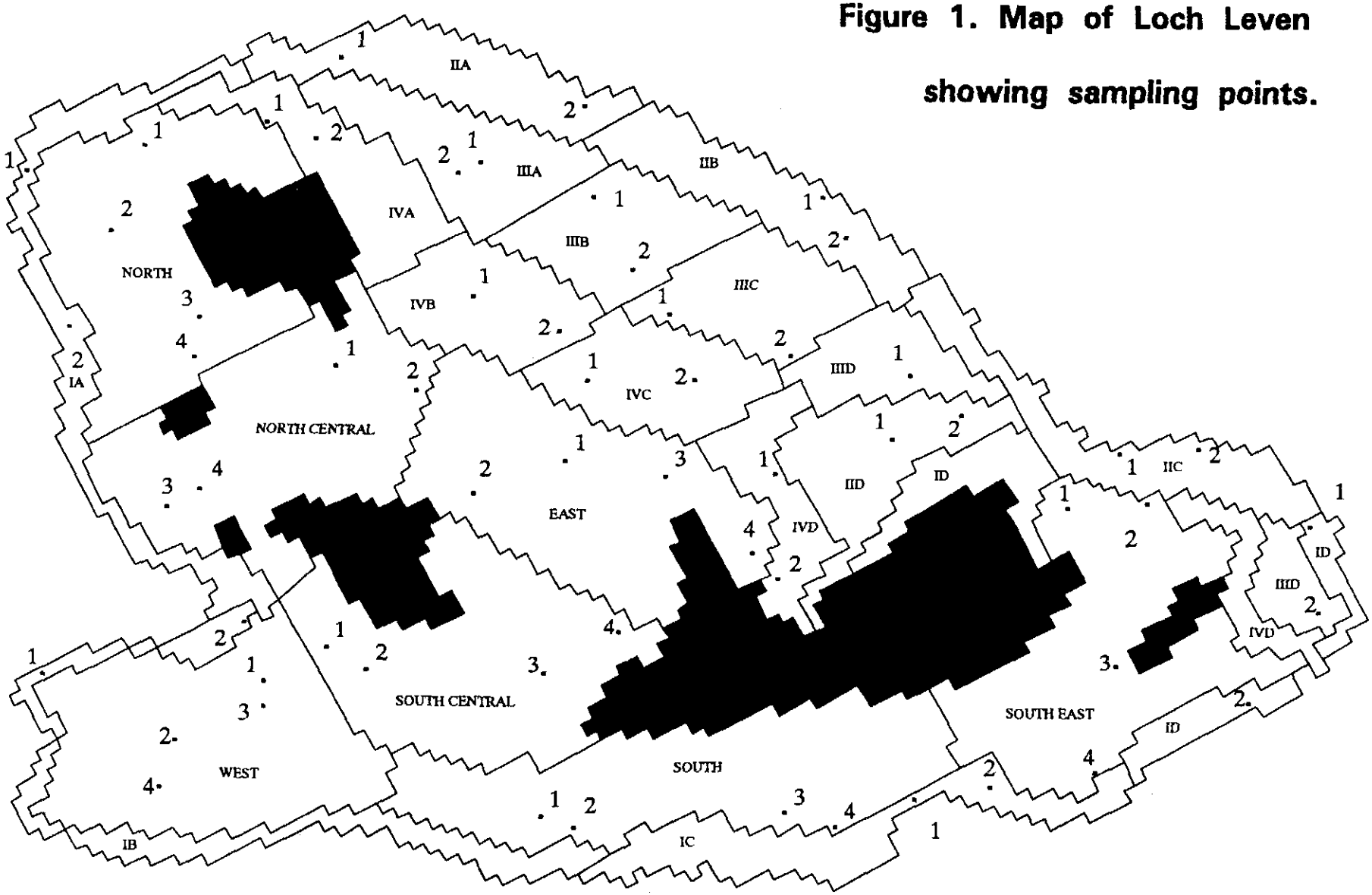

Table 2. Location and water depth of 5-cm depth Jenkin core mud samples. All samples taken on the 5th of May 1994

SITE	WATER DEPTH(m)	GRID REF. E-W	GRID REF. N-S
N (1)	4.30	313830	703618
(2)	3.80	313537	703389
(3)	4.10	313662	702875
(4)	3.55	313584	702740
NC (1)	4.80	314066	702404
(2)	4.90	314304	702152
(3)	3.30	313187	702227
(4)	3.55	313347	702201
W (1)	3.55	313198	701362
(2)	3.30	312732	701302
(3)	3.50	313129	701298
(4)	3.05	312581	701181
E (1)	5.80	314739	701627
(2)	5.05	314335	701677
(3)	6.80	315056	701399
(4)	7.40	315230	700927
SC (1)	3.90	313498	701394
(2)	4.00	313584	701222
(3)	5.40	314235	700892
(4)	5.80	314576	700855
S (1)	3.70	313941	700304
(2)	3.80	314049	700243
(3)	4.20	314833	699852
(4)	3.80	314955	699746
SE (1)	3.30	316469	700470
(2)	3.50	316768	700321
(3)	10.30	316434	699778
(4)	3.05	316016	699444

Table 3. Date, location, Maitland core and water depths of sand samples.

SITE	DATE	WATER DEPTH(m)	CORE DEPTH(m)	GRID REF. E - W	GRID REF. N - S
IA (1)	6.5.94	1.75	8.00	313338	703775
(2)	6.5.94	1.20	10.00	313177	703060
IB (1)	6.5.94	1.80	8.00	312368	701821
(2)*	6.5.94	3.40	5.00	313220	701621
IC (1)	6.5.94	1.50	6.00	315326	699700
(2)	6.5.94	1.40	7.50	315635	699556
ID (1)	9.5.94	0.88	10.00	317337	699909
(2)	6.5.94	1.00	7.50	316727	699389
IIA (1)	9.5.94	1.15	6.00	314745	703560
(2)	9.5.93	1.30	9.50	315510	702945
IIB (1)	9.5.94	0.75	10.00	316213	702101
(2)	9.5.94	0.86	10.50	316203	701903
IIC (1)	9.5.94	1.07	11.00	316765	700564
(2)	9.5.94	0.95	7.00	317095	700408
IID (1)	9.5.94	1.01	10.00	315995	701084
(2)	9.5.94	1.02	10.50	316284	701036
IIIA (1)	9.5.94	2.05	6.50	315045	702905
(2)	9.5.94	2.00	6.50	314936	702913
IIIB (1)	9.5.94	2.40	5.00	315365	702586
(2)	9.5.94	2.20	6.50	315386	702210
IIIC (1)	9.5.94	2.20	7.00	315412	701999
(2)	9.5.94	1.80	11.00	315770	701573
IIID (1)	9.5.94	1.75	7.50	316185	701253
(2)	6.5.94	2.60	6.50	317186	699580
IVA (1)	9.5.94	2.30	11.50	314342	703492
(2)	9.5.94	2.30	6.00	314457	703328
IVB (1)	9.5.94	2.55	5.00	314706	702426
(2)	9.5.94	2.40	6.50	314955	702149
IVC (1)	9.5.94	2.30	7.00	314987	701883
(2)	9.5.94	2.00	6.00	315375	701687
IVD (1)	9.5.94	1.40	10.00	315463	701151
(2)	9.5.94	1.90	6.50	315287	700773

* Sample IB(2) was taken from a muddy sediment - sampled using a Jenkin corer.

2.2. Processing and identification of samples

The invertebrates were separated from the sand by a simple decantation method described in detail by Maitland *et al.* (1972). The benthos was separated from the muds by washing the samples through a 0.5 mm mesh sieve. The animals were then sorted into taxonomic groups, identified, counted and recorded. The level of identification varied according to the taxonomic difficulty of the respective invertebrate groups and the limited time available. Identification of the Chironomidae was taken to Genus level based on Wiederholm (1983). Specimens of Chironomidae larvae from each sample site were initially placed in a concentrated solution of potassium hydroxide (to clear the internal tissues allowing a better view of the surface structures important in identification); the head capsule was dissected from the body and mounted in polyvinyl lactophenol. All the oligochates were identified to Family level with approximately 30 samples being also examined in more detail for species composition using the key of Brinkhurst (1971). Species level identification of oligochaetes was only possible with mature specimens. Identification of *Pisidium* specimens from the mud was impossible due to decalcification of the shells. *Pisidium* from the sand have yet to be identified. Most of the other taxa were identified to species level using the relevant FBA keys. After identification samples were retubed and stored in a 50:50 mixture of 70% alcohol and glycerol.

3. RESULTS OF SURVEY AND COMPARISONS WITH IBP INVERTEBRATE DATA

3.1. Species composition

Table (4) gives the list of invertebrate taxa recorded during the benthos survey in May 1994.

Table 4. Invertebrate taxa recorded from Loch Leven, May 1994

	Sand	Mud
NEMATODA	✓	✓
MOLLUSCA		
GASTROPODA		
Valvata piscinalis (Muller)	✓	✓
Potamopyrgus jenkinsi (Smith)	✓	-
Lymnaea peregra (Muller)	✓	-
BIVALVIA		
Sphaerium sp.	-	✓
Pisidium spp.	✓	✓
ANNELIDA		
OLIGOCHAETA		
Naididae		
Uncinais uncinata	✓	-
Tubificidae		
Aulodrilus pluriseta (Piguet)	-	✓
Potamothrix hammoniensis (Michaelsen)	-	✓
Limnodrilus claparedeianus Ratzel	-	✓
Limnodrilus hoffmeistrei Claperède	✓	-
Psammoryctides barbatus (Grube)	✓	✓
Potamothrix/Tubifex group*	✓	✓
Limnodrilus/P.moldaviensis group*	✓	-
Enchytraeidae	✓	-
Lumbriculidae		
Lumbriculus variegatus (Muller)	✓	✓
HIRUDINEA		
Glossiphonia complanata (L.)	-	✓
Helobdella stagnalis (L.)	✓	✓
Erpobdella octoculata (L.)	✓	-
HYDRACARINA	-	✓
ARTHROPODA		
CRUSTACEA		
Ostracoda	-	✓
Malacostraca		
Asellus aquaticus L.	-	✓
INSECTA		
Ephemeroptera		
Caenis horaria (L.)	-	✓
Caenis luctuosa (Burmeister)	-	✓
Trichoptera		
Oecetis ochracea Curtis	✓	✓
Diptera		
Chironomidae		
Tanypodinae		
Procladius sp.	✓	✓
Orthocladiinae		
Psectrocladius sp.	✓	-
Chironominae		
Chironomus sp.	✓	✓
Cladotanytarsus sp.	✓	-
Cryptochironomus sp.	✓	✓
Dicrotendipes sp.	✓	✓
Endochironomus sp.	✓	✓
Glyptotendipes sp.	✓	✓
Paracladopelma sp.	✓	-
Polypedilum sp.	✓	-
Stictochironomus sp.	✓	-
Tanytarsus sp.	-	✓
Ceratopogonidae	✓	✓

* Immature specimens

N. B. *Dicrotendipes* was formerly known as *Limnochironomus*.

The above species list is broadly similar to that published by

Maitland and Hudspith (1974) for the period 1966-1972, although it contains no species of a number of groups (e.g. Corixidae, *Gammarus* and Dytiscidae) which are normally associated with shallower littoral regions, a habitat not included in the present survey. However, there were a number of changes in the species composition, particularly in the chironomid and oligochaete fauna, associated with the sandy and muddy substrates. Previously un-recorded chironomid taxa found in the sand were *Paracladopelma* (Chironominae), *Cladotanytarsus* (Chironominae) and *Psectrocladius* (Orthocladiinae). Both *Cladotanytarsus* and *Psectrocladius* are likely to have been present in Loch Leven during the IBP studies but due to the then lack of suitable larval keys to their respective groups i.e. Tanytarsini and Orthocladiiinae, identification to genera level was not possible. However, *Paracladopelma* is a new taxa for Loch Leven, and is regarded as being relatively intolerant genera of eutrophication (Wiederholm, 1983). One other chironomid of interest is the reappearance of *Endochironomus* in both the sand and mud, which though common in Loch Leven during 1967 and 1968, disappeared in 1969 and was not recorded in subsequent years. Three 'new' oligochaete taxa were noted, namely the naid *Uncinais ucinata* in the sand and the tubificids *Psammoryctides barbatus* and *Limnodrilus claparedeianus*, in the sand/mud and mud respectively. All three species would appear to be tolerant of eutrophic conditions, as *Uncinais* and *Psammorcytides* were found in similar sandy sediments in Lough Neagh (Carter and Murphy, 1993) and *Limnodrilus claparedeianus* was recorded in Eglwys Nunydd Reservoir (Potter and Learner, 1974). Both these are well known shallow eutrophic waterbodies whose invertebrate fauna has been intensively studied. *Uncinais uncinata* was also of taxonomic interest in that a number of specimens, though possessing characteristic features such as eyes and lack of hair chaetae, had, unusually, dorsal chaetae beginning in segment V rather than segment VI. The naids *Stylaria lacustris*, *Nais paradalis* and *Nais variabilis*, found during the IBP studies, were not recorded in the present study. A number of other invertebrate taxa not found during the May 1994 survey, were as follows:

Hydra (Coelenterata)
Rhabdocoela (Platyhelminthes)
Diamesa (Diamesinae)
Microtendipes (Chironominae)
Harnischia (Chironominae)
Microspectra (Tanytarsini)
Pentaneura (Tanypodinae)
Psilotanypus (Tanypodinae)

The present survey represents the situation as of the beginning of May, 1994 - it does not preclude the possibility of these invertebrates being present at other times of the year. For example, *Hydra* and Rhabdocoela were not recorded in May of 1970 and 1971 but were found in October 1968.

3.2. Abundance and Distribution

Table (5) summarises the distribution and abundance of the benthos in the sand and mud areas.

Table 5. Abundance and distribution of invertebrates from Loch Leven, May 1994

	Sand		Mud	
	Nos	Nos/m^2	Nos	Nos/m^2
GASTROPODA				
Valvata	4	34	21	188
Potamopyrgus	3	25	0	-
Lymnaea	1	8	0	-
BIVALVIA				
Sphaerium	-	-	2	18
Pisidium	195	1,635	66	592
OLIGOCHAETA				
Naididae	79	662	-	-
Tubificidae	614	5,149	578	5,182
Enchytraeidae	50	419	-	-
Lumbriculidae	70	587	1	9
HIRUDINEA				
Glossiphonia	-	-	1	9
Helobdella	4	34	11	99
Erpobdella	7	59	-	-
CRUSTACEA				
Asellus	-	-	1	9
Ostracoda	-	-	2	18
EPHEMEROPTERA				
Caenis	-	-	2	18
TRICHOPTERA				
Oecetis	3	25	2	18
DIPTERA				
Procladius	7	59	458	4,106
Psectrocladius	9	75	-	-
Chironomus	1	8	65	583
Cladotanytarsus	1,322	11,086	-	-
Cryptochironomus	21	176	1	9
Dicrotendipes	9	75	7	63
Endochironomus	2	17	1	9
Glyptotendipes	1	8	1	9
Paracladopelma	10	84	-	-
Polypedilum	1	8	-	-
Stictochironomus	336	2,818	-	-
Tanytarsus	-	-	136	1,219
Ceratopogonidae	17	143	2	18
NEMATODA	975	8,176	5	42

The invertebrate taxa recorded at each individual sampling point are shown in **Appendices 1** and **2**, grouped together according to sample area.

3.2.1. Abundance of invertebrates

The dominant invertebrates in terms of abundance are Nematoda, Oligochaeta (mainly Tubificidae), Diptera (mainly Chironomidae) and Mollusca (mainly *Pisidium* and *Valvata*). Other animals recorded in lesser numbers were Hirudinea, Ephemeroptera (*Caenis*), Trichoptera (*Oecetis*) and Crustacea (*Asellus*). In terms of biomass, though this was not measured with any accuracy, Diptera and Oligochaeta were clearly dominant. Comparisons with data derived from the IBP studies (see **Table 6**) indicate that the relative proportions of the constituent groups of the Loch Leven benthos are much the same as before. Total invertebrate numbers are much more variable, for example, numbers in the sandy areas in May 1994 are similar to 1970, much higher than 1971 but considerably less than in the 1968 survey.

Table 6. Numbers per square metre of invertebrate benthos in Loch Leven

	May 1994		Oct. 1968		1970	1971
	Sand	Mud	Sand	Mud	Sand	Sand
Nematoda	8,176	42	34,953	2,650	285	907
Gastropoda	677	188	255	545	122	230
Pisidium	1,635	592	995	1,145	344	829
Oligochaeta	6,867	5,200	25,934	13,631	3,597	2,904
Hirudinea	93	108	158	163	77	47
Chironomidae	14,414	5,998	21,411	11,240	24,400	13,973
Others	168	81	1581	3351	315	360
Totals	31,339	12,194	85,287	32,725	29,241	19250

N.B. The figures for 1970 and 1971 are annual means

More detailed comparisons can be made for the larval Chironomidae, as much of the later IBP invertebrate work concentrated on studies of their production.

(a) Sand

The four main genera in the sandy areas in 1970 and 1971 were *Glypotendipes*, *Stictochironomus*, *Limnochironomus* (synonymous with *Dicrotendipes*) and *Cryptochironomous*. Tanytarsini though important numerically, were less so in terms of biomass and caused difficulties in producing production estimates (Maitland and Hudspith, 1974). Numerical comparisons with the present survey are shown in **Table 7**.

Table 7. Numbers per square metre of larval Chironomidae in the sand area of Loch Leven

	May 1994	Oct. 1968	May 1970	May 1971
Procladius	59	828	18	173
Orthocladiinae	75	470	262	3
Chironomus	8	25	0	0
Tanytarsini	11,086	11,333	10,267	4,870
Cryptochironomus	176	428	514	629
Dicrotendipes	75	600	138	8
Endochironomus	17	208	0	0
Glyptotendipes	8	4,515	5,134	607
Paracladopelma	84	0	0	0
Polypedilum	8	298	0	0
Stictochironomus	2,818	2,543	352	109

Comparsions with the present larval Chironomidae population of the sandy regions reveal that *Dicrotendipes* and *Cryptochironomus* numbers are somewhat similar. However, *Stictochironomus* is more numerous than previously, unlike *Glypotendipes* whose numbers have dropped dramatically to only $8/m^2$ compared to $5,314/m^2$ in May 1970. Tanytarsini remain as numerically important as in the IBP study.

(b) Mud

Production studies in the muddy sediments of Loch Leven during 1971-1972 concentrated on the four dominant larval Chironomidae genera found in the early years of the IBP study i.e. *Chironomus, Glyptotendipes, Polypedilum* and *Limnochironomus (Dicrotendipes)*. During this period there was a marked decline in *Glyptotendipes* numbers and is now virtually absent from the mud (see **Table 8**) *Polypedilum* has disappeared, whereas it was a common genera in the past (see **Table 8**). A possible explanation for this is that the survey took place close to the time that chironomid larvae emerge, however *Chironomus* and *Dicrotendipes*, which have similar life cycle patterns in Loch Leven to *Glypotendipes* and *Polypedilum* (Charles *et al*, 1974), were present in reasonable numbers, suggesting that is not the case.

Table 8. Numbers per square metre of larval Chironomidae in the mud area of Loch Leven

	May 1994	Oct. 1968	Nov. 1971
Tanypodinae	4,106	4,338	9,474
Orthocladiinae	0	50	?
Chironomus	583	318	7,395
Tanytarsini	1,219	1,668	589
Cryptochironomus	9	60	15
Dicrotendipes	63	588	705
Endochironomus	9	195	0
Glyptotendipes	9	2,310	61
Polypedilum	0	1,713	587

3.2.2. Distribution of invertebrates

Comparisons between the communities associated with the sand and mud zones show some clear differences (see **Tables 4** and **5**). The invertebrates either occur over both sand and mud substrates or exhibit a preference for, or are restricted to, a particular sediment type:

Sand/mud	Sand	Mud
Valvata	Nematoda	*Procladius*
Pisidium	*Uncinais*	*Chironomus*
Helobdella	Lumbriculidae	*Tanytarsus*
Oecetis	*Erpobdella*	*Aulodrilus*
Dicrotendipes	*Psectrocladius*	*Potamothrix hamm.*
Endochironomus	*Cladotanytarsus*	
Potamothrix/Tubifex	*Cryptochironomus*	
	Paracladopelma	
	Stictochironomus	
	Ceratopogonidae	
	Enchytraeidae	
	Psammorcytides	
	Limnodrilus/Potamothrix	

Although there are some minor differences (e.g. Lumbriculidae showing a preference for sand), the above invertebrate distributional pattern is very similar to the one described by Maitland and Hudspith (1974). There are however, distinct disributional patterns shown by species within the Tubificidae (e.g. *Aulodrilus pluriseta* for muddy substrates), trends not apparent previously. This is due to the lack of taxonomic penetration of the Oligochaeta group in the earlier study. Other distributional patterns may be revealed when other invertebrate groups, where there is presently no obvious association with substrate type, are identified to species level e.g. *Pisidium*.

4. ACKNOWLEDGEMENTS

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APPENDICES

APPENDIX 1.
Invertebrate taxa found in the muddy sediments

	East (1)	East (2)	East (3)	East (4)
Valvata	1	-	-	-
Pisidium	-	1	3	7
Sphaerium	1	-	-	-
Tubificidae	13	24	16	15
Lumbriculidae	-	1	-	-
Helobdella	-	1	-	-
Procladius	14	20	21	29
Chironomus	1	-	-	2
Tanytarsus	4	5	5	2

	West (1)	West (2)	West (3)	West (4)
Valvata	-	-	1	-
Pisidium	1	-	-	1
Tubificidae	18	46	19	22
Helobdella	1	3	-	-
Caenis	-	-	1	-
Oecetis	-	-	1	-
Procladius	18	17	12	10
Chironomus	7	6	6	1
Dicrotendipes	-	7	-	-
Tanytarsus	2	3	-	2

	South(1)	South(2)	South(3)	South(4)
Valvata	3	-	3	1
Sphaerium	-	-	1	-
Pisidium	4	4	3	-
Tubificidae	40	23	26	17
Helobdella	-	-	1	1
Caenis	-	1	-	-
Procladius	11	19	6	4
Chironomus	1	3	-	2
Tanytarsus	-	10	4	1
Nematoda	-	-	-	2

	North(1)	North(2)	North(3)	North(4)
Valvata	-	1	1	2
Pisidium	1	1	1	2
Tubificidae	8	19	17	7
Nematoda	3	-	-	-
Helobdella	1	-	1	-
Procladius	19	13	12	14
Chironomus	-	4	-	2
Glptotendipes	1	-	-	-
Tanytarsus	3	-	5	4

	S.East(1)	S.East(2)	S.East(3)	S.East(4)
Valvata	2	1	2	2
Pisidium	2	2	9	1
Tubificidae	10	12	13	48
Helobdella	-	-	1	-
Oecetis	-	1	-	-
Ceratopogodinae	-	-	-	2
Procladius	13	21	40	1
Chironomus	1	4	3	1
Endochironomus	-	1	-	-
Tanytarsus	6	25	4	1
Ostracoda	1	1	-	-

	S.Cent.(1)	S.Cent(2)	S.Cent.(3)	S.Cent.(4)
Pisidium	-	1	2	5
Tubificidae	13	17	34	24
Helobdella	1	-	2	1
Asellus	-	-	1	-
Procladius	12	5	18	12
Chironomus	-	4	2	1
Tanytarsus	1	1	7	5
Hydracarina	-	1	-	-

	N.Cent.(1)	N.Cent(2)	N.Cent.(3)	N.Cent.(4)
Valvata	-	-	1	-
Pisisium	5	1	2	2
Tubificidae	15	10	12	18
Procladius	18	14	23	20
Chironomus	1	2	5	4
Cryptochironomus	1	-	-	-
Tanytarsus	5	10	4	9

APPENDIX 2.
Invertebrate taxa found in sandy sediments

	IA		IB		IC		ID	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Valvata	-	-	3	-	-	-	-	-
Potamopyrgus	-	-	2	-	-	-	-	-
Pisidium	13	2	1	1	6	10	-	9
Naididae	-	-	-	-	-	-	4	-
Tubificidae	6	8	3	21	16	13	4	13
Lumbriculidae	5	2	2	-	1	-	1	2
Nematoda	37	11	7	-	86	39	3	47
Ceratopogodinae	1	-	4	-	1	-	-	1
Procladius	-	-	-	22	-	-	-	-
Psectrocladius	-	1	1	-	2	-	-	4
Chironomus	-	-	-	2	-	-	-	-
Cladotanytarsus	37	26	15	-	35	36	8	29
Cryptochironomus	1	-	-	-	1	-	1	1
Dicrotendipes	-	-	2	-	-	-	-	-
Paracladopelma	-	2	-	-	-	-	-	-
Stictochironomus	24	45	-	-	12	3	32	7
Tanytarsus	-	-	-	8	-	-	-	-
Enchytraeidae	-	-	-	-	-	-	3	-

	IIA		IIB		IIC		IID	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Pisidium	-	2	1	1	-	4	10	4
Naididae	9	9	-	1	-	-	4	3
Tubificidae	17	9	-	7	7	41	39	27
Lumbriculidae	2	1	-	1	4	2	2	2
Nematoda	45	19	22	10	58	40	86	27
Ceratopogodinae	-	-	-	-	1	6	-	-
Cladotanytarsus	45	36	33	9	12	28	160	221
Crytochironomus	-	4	-	-	-	-	1	-
Paracladopelma	-	1	-	3	-	-	-	1
Stictochironomus	-	24	33	9	48	41	21	17
Enchytraeidae	4	2	2	-	-	1	-	-

	IIIA		IIIB		IIIC		IIID	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Lymnaea	1	-	-	-	-	-	-	-
Potamopyrgus	-	-	-	1	-	-	-	-
Pisidium	15	8	9	12	7	7	2	4
Naididae	6	4	-	6	6	2	-	-
Tubificidae	29	13	24	13	10	48	61	2
Lumbriculidae	3	3	8	-	3	-	3	-
Enchytraeidae	-	-	-	-	1	-	-	-
Nematoda	48	63	36	44	57	43	22	3
Helobdella	-	-	-	1	-	-	2	-
Erpobdella	-	-	5	-	-	-	-	-
Oecetis	1	-	1	-	-	-	1	-
Ceratopogodinae	-	-	-	-	-	-	-	1
Procladius	-	-	-	1	2	-	1	-
Cladotanytarsus	60	29	46	50	36	63	64	11
Crytochironumus	1	1	-	-	1	1	-	-
Dicrotendipes	-	-	-	-	2	1	-	2

Endochironomus	-	-	-	1	-	-	1	-
Glypotendipes	1	-	-	-	-	-	-	-
Stictochironomus	2	6	-	2	2	2	3	-

	IVA		IVB		IVC		IVD	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Valvata	-	-	-	-	-	1	-	-
Pisidium	9	10	8	8	7	32	4	-
Naididae	-	7	2	-	1	6	9	-
Tubificidae	21	22	40	26	23	79	-	8
Lumbriculidae	15	2	3	-	-	3	-	-
Nematoda	31	25	1	18	12	-	15	20
Helobdella	-	-	-	1	-	-	-	-
Erpobdella	2	-	-	-	-	-	-	-
Ceratopogodinae	-	1	-	1	-	-	-	-
Procladius	-	-	2	1	-	-	-	-
Chironomus	-	1	-	-	-	-	-	-
Cladotanytarsus	48	56	18	30	27	47	5	2
Crytochironomus	2	1	-	1	-	4	-	-
Dicrotendipes	2	-	-	-	-	-	-	-
Paracladopelma	-	-	-	-	-	-	2	1
Polypedilum	-	1	-	-	-	-	-	-
Psectrocladius	-	-	-	-	-	-	-	1
Stictochironomus	-	1	-	1	1	1	3	3
Enchytraeidae	-	-	-	-	-	1	29	7

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